

LEVELS OF REALITY AS SOURCE OF QUANTUM INDETERMINACY*

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1 Quantum physics and levels of Reality

The major cultural impact of the quantum physics has certainly raised questions for the contemporary philosophical dogma of the existence of a single level of Reality [1].

Here the meaning we give to the word "Reality" is pragmatic and ontological at the same time.

By Reality I intend first of all to designate that which resists our experiences, representations, descriptions, images or mathematical formalizations. Quantum physics caused us to discover that abstraction is not simply an intermediary between us and Nature, a tool for describing reality, but rather, one of the constituent parts of Nature. In quantum physics, mathematical formalization is inseparable from experience. It resists in its own way by its simultaneous concern for internal consistency, and the need to integrate experimental data without destroying that self-consistency.

In so far as Nature participates in the being of the world one must ascribe an ontological dimension to the concept of Reality. Nature is an immense, inexhaustible source of the unknown which justifies the very existence of science. Reality is not only a social construction, the consensus of a collectivity, or an intersubjective agreement. It also has a trans-subjective dimension, to the extent that one simple experimental fact can ruin the most beautiful scientific theory.

By *level of Reality* [1] I intend to designate an ensemble of systems which are invariant under the action of certain general laws: for example, quantum entities are subordinate to quantum laws, which depart radically from the laws of the macrophysical world. That is to say that two levels of Reality are *different* if, while passing from one to the other, there is a break in the laws and a break in fundamental concepts (like, for example, causality). No one has succeeded in finding a mathematical formalism which permits the rigorous passage from one world to another. Semantic glosses, tautological definitions or approximations are unable to replace a rigorous mathematical formalism. The recent decoherence models have nothing precise to say on the passage between the quantum level and the macrophysical level: in fact, the main problem is not decoherence but precisely *coherence*.

There are even strong mathematical indications that the continuous passage from the quantum world to the macrophysical world would never be possible. But there is nothing catastrophic about this. The *discontinuity* which is manifest in the quantum world is also manifest in the structure of

the levels of Reality. That does not prevent the two worlds from co-existing.

The levels of Reality are radically different from the levels of organization as these have been defined in systemic approaches [2]. Levels of organization do not presuppose a break with fundamental concepts: several levels of organization appear at one and the same level of Reality. The levels of organization correspond to different structurings of the same fundamental laws. For example, Marxist economy and classical physics belong to one and the same level of Reality.

The emergence of at least two different levels of Reality in the study of natural systems is a major event in the history of knowledge.

The existence of different levels of Reality has been affirmed by different traditions and civilizations, but these affirmations were founded on religious dogma or on the exploration of the interior universe.

In our century, in their questioning of the foundations of science, Edmund Husserl [3] and other scholars have discovered the existence of different levels of perception of Reality by the subject-observer. But these thinkers, pioneers in the exploration of a multi-dimensional and multi-referential reality, have been marginalized by academic philosophers and misunderstood by the majority of physicists, enclosed in their respective specializations. The view I am expressing here is totally conform to the one of Heisenberg, Pauli and Bohr.

In fact, Werner Heisenberg came very near, in his philosophical writings, to the concept of "level of Reality". In his famous *Manuscript of the year 1942* (published only in 1984) Heisenberg, who knew well Husserl, introduces the idea of three *regions of reality*, able to give access to the concept of "reality" itself: the first region is that of classical physics, the second - of quantum physics, biology and psychic phenomena and the third - that of the religious, philosophical and artistic experiences [4]. This classification has a subtle ground: the closer and closer connectiveness between the Subject and the Object.

As we shall see in the following, the notion of levels of Reality will lead us to a general philosophical understanding of the nature of indeterminacy. If there was only one region or level of reality, it was impossible to conceive what means a true, irreducible indeterminacy, like the quantum one.

2 The logic of the included middle

Knowledge of the coexistence of the quantum world and the macrophysical world and the development of quantum physics has led, on the level of theory and scientific experiment, to the upheaval of what were formerly considered to be *pairs of mutually exclusive contradictories* (A and non-A): wave *and* corpuscle, continuity *and* discontinuity, separability *and* nonseparability, local causality *and* global causality, symmetry *and* breaking of symmetry, reversibility *and* irreversibility of time, etc.

The intellectual scandal provoked by quantum mechanics consists in the fact that the pairs of contradictories that it generates are actually mutually contradictory when they are analyzed through the interpretative filter of classical logic. This logic is founded on three axioms:

1. *The axiom of identity* : A is A.
2. *The axiom of non-contradiction* : A is not non-A.
3. *The axiom of the excluded middle* : There exists no third term T which is at the same time A and non-A.

Under the assumption of the existence of a single level of Reality, the second and third axioms are obviously equivalent.

If one accepts the classical logic one immediately arrives at the conclusion that the pairs of contradictories advanced by quantum physics are mutually exclusive, because one cannot affirm the validity of a thing and its opposite at the same time: A *and* non-A.

Since the definitive formulation of quantum mechanics around 1930 the founders of the new science have been acutely aware of the problem of formulating a new, "quantum logic." Subsequent to the work of Birkhoff and van Neumann a veritable flourishing of quantum logics was not long in coming [5]. The aim of these new logics was to resolve the paradoxes which quantum mechanics had created and to attempt, to the extent possible, to arrive at a predictive power stronger than that afforded by classical logic.

Most quantum logics have modified the second axiom of classical logic – the axiom of non-contradiction – by introducing non-contradiction with several truth values in place of the binary pair (A, non-A). These multivalent logics, whose status with respect to their predictive power remains controversial, have not taken into account one other possibility: the modification of the third axiom – the axiom of the excluded middle.

History will credit Stéphane Lupasco with having shown that the *logic of the included middle* is a true logic, formalizable and formalized, multivalent (with three values: A, non-A, and T) and non-contradictory [6]. His philosophy, which takes quantum physics as its point of departure, has been marginalized by physicists and philosophers. Curiously, on the other hand, it has had a powerful albeit underground influence among psychologists, sociologists, artists, and historians of religions. Perhaps the absence of the notion of "levels of Reality" in his philosophy obscured its substance: many persons wrongly believed that Lupasco's logic violated the principle of non-contradiction.

Our understanding of the axiom of the included middle – *there exists a third term T which is at the same time A and non-A* – is completely clarified once the notion of "levels of Reality" is introduced.

In order to obtain a clear image of the meaning of the included middle, we can represent the three terms of the new logic – A, non-A, and T – and the dynamics associated with them by a triangle in which one of the vertices is situated at one level of Reality and the two other vertices at another level of Reality. If one remains at a single level of Reality, all manifestation appears as a struggle between two contradictory elements (example: wave A and corpuscle non-A). The third dynamic, that of the T-state, is exercised at another level of Reality, where that which appears to be disunited (wave or corpuscle) is in fact united (quanton), and that which appears contradictory is perceived as non-contradictory.

It is the projection of T on one and the same level of Reality which produces the appearance of mutually exclusive, antagonistic pairs (A and non-A). A single level of Reality can only create antagonistic oppositions. It is inherently *self-destructive* if it is completely separated from all the other levels of Reality. A third term, let us call it T_0 , which is situated on the same level of Reality as that of the opposites A and non-A, can not accomplish their reconciliation.

The T-term is the key in understanding indeterminacy: being situated on a different level of Reality than A and non-A, it necessarily induces an *influence* of its own level of Reality upon its neighbouring and different level of Reality: *the laws of a given level are not self-sufficient to describe the phenomena occurring at the respective level.*

The entire difference between a triad of the included middle and an Hegelian triad is clarified by consideration of the role of *time*. *In a triad of the included middle the three terms coexist at the same moment in time.*

On the contrary, each of the three terms of the Hegelian triad succeeds the former in time. This is why the Hegelian triad is incapable of accomplishing the reconciliation of opposites, whereas the triad of the included middle is capable of it. In the logic of the included middle the opposites are rather *contradictories* : the tension between contradictories builds a unity which includes and goes beyond the sum of the two terms. The Hegelian triad would never explain the nature of indeterminacy.

One also sees the great dangers of misunderstanding engendered by the common enough confusion made between the axiom of the excluded middle and the axiom of non-contradiction . The logic of the included middle is non-contradictory in the sense that the axiom of non-contradiction is thoroughly respected, a condition which enlarges the notions of "true" and "false" in such a way that the rules of logical implication no longer concerning two terms (A and non-A) but three terms (A, non-A and T), co-existing at the same moment in time. This is a formal logic, just as any other formal logic: its rules are derived by means of a relatively simple mathematical formalism.

One can see why the logic of the included middle is not simply a metaphor, like some kind of arbitrary ornament for classical logic, which would permit adventurous incursions into the domain of complexity. *The logic of the included middle is the privileged logic of complexity*, privileged in the sense that it allows us to cross the different areas of knowledge in a coherent way, by enabling a new kind of simplicity.

The logic of the included middle does not abolish the logic of the excluded middle: it only constrains its sphere of validity. The logic of the excluded middle is certainly valid for relatively simple situations. On the contrary, the logic of the excluded middle is harmful in complex, transdisciplinary cases. For me, the problem of indeterminacy is precisely belonging to this class of cases.

3 The Gödelian unity of the world

The transdisciplinary approach [7] sets forth for consideration a multi-dimensional Reality, structured by multiple levels replacing the single level of classical thought – one-dimensional reality. This proposal is not enough, by itself, to justify a new vision of the world. We must first of all answer many questions in the most rigorous possible way. What is the nature of the theory which can describe the passage from one level of Reality to another? Is there

truly a coherence, a unity of the totality of levels of Reality? What is the role of the subject-observer of Reality in the dynamics of the possible unity of all the levels of Reality? Is there a level of Reality which is privileged in relation to all other levels? What is the role of reason in the dynamics of the possible unity of knowledge? What is the predictive power of the new model of Reality in the sphere of reflection and action? Finally, is understanding of the present world possible ?

According to our model, Reality comprises a certain number of levels [1,2]. The considerations which follow do not depend on whether or not this number is finite or infinite. For the sake of clarity, let us suppose that this number is infinite.

Two adjacent levels are connected by the logic of the included middle in the sense that the T-state present at a certain level is connected to a pair of contradictories (A and non-A) at the immediately adjacent level. The T-state operates the unification of contradictories A and non-A but this unification is operated at a level *different* from the one on which A and non-A are situated. The axiom of non-contradiction is thereby respected. Does this fact signify that we can obtain a complete theory, which will be able to account for all known and forthcoming results ?

There is certainly a coherence between different levels of Reality, at least in the natural world. In fact, an immense *self-consistency* – a cosmic bootstrap – seems to govern the evolution of the universe, from the infinitely small to the infinitely large, from the infinitely brief to the infinitely long [1]. A flow of information is transmitted in a coherent manner from one level of Reality to another level of Reality in our physical universe.

The logic of the included middle is capable of describing the coherence between the levels of Reality by an iterative process defined by the following stages: 1. A pair of contradictories (A, non-A) situated at a certain level of reality is unified by a T-state situated at a contiguous level of Reality; 2. In turn, this T-state is linked to a couple of contradictories (A', non-A'), situated at its own level; 3. The pair of contradictories (A', non-A') is, in its turn, unified by a T'-state situated at a different level of Reality, immediately contiguous to that where the ternary (A', non-A', T) is found. The iterative process continues indefinitely until all the levels of Reality, known or conceivable, are exhausted.

In other terms, the action of the logic of the included middle on the different levels of Reality induces an *open, Gödelian* structure of the unity of levels of Reality. This structure has considerable consequences for the theory

of knowledge because it implies the impossibility of a complete theory, closed in upon itself.

In effect, in accordance with the axiom of non-contradiction, the T-state realizes the unification of a pair of contradictories (A, non-A) but it is associated, at the same time with another pair of contradictories (A', non-A'). This signifies that starting from a certain number of mutually exclusive pairs one can construct a new theory which eliminates contradictions at a certain level of Reality, but this theory is only temporary because it inevitably leads, under the joint pressure of theory and experience, to the discovery of new levels of contradictories, situated at a new level of Reality. In turn this theory will therefore be replaced by still more unified theories as new levels of Reality are discovered. This process will continue indefinitely without ever resulting in a completely unified theory. The axiom of non-contradiction is increasingly strengthened during this process. In this sense, without ever leading to an absolute non-contradiction, we can speak of an *evolution of knowledge* which encompasses all the levels of Reality: knowledge which is forever open. Finer matter penetrates coarser matter, just as quantum matter penetrates macrophysical matter, but the reverse is not true. *Degrees of materiality* induce an orienting arrow for tracing the transmission of information from one level to the other. This orienting arrow is associated with the discovery of more and more general, unifying, and encompassing laws.

The open structure of the unity of levels of Reality is in accord with one of the most important scientific results of the 20th century concerning arithmetic, the theorem of Kurt Gödel [8]. Gödel's theorem tells us that a sufficiently rich system of axioms inevitably lead to results which would be either undecidable or contradictory. The implications of Gödel's theorem have considerable importance for all modern theories of knowledge. First of all it does not only concern the field of arithmetic but also all mathematics which includes arithmetic. Now, obviously the mathematics which underlies theoretical physics include arithmetic. This means that all research for a complete physical theory is illusory.

In fact, the search for an axiomatic system leading to a complete theory (without undecidable or contradictory results) marks at once the apex and the starting point of the decline of classical thought. The axiomatic dream is unraveled by the verdict of the holy of holies of classical thought – mathematical rigor.

The theorem that Kurt Gödel demonstrated in 1931 sounded only a faint echo beyond a very limited circle of specialists. The difficulty and extreme

subtlety of its demonstration explains why this theorem has taken a certain time to be understood within the mathematical community. Today, it has scarcely begun to penetrate the world of physicists. Wolfgang Pauli, one of the founders of quantum mechanics, was one of the first physicists to understand the extreme importance Gödel's theorem has for the construction of physical theories [9].

The Gödelian structure of the unity of levels of Reality associated with the logic of the included middle implies that it is impossible to construct a complete theory for describing the passage from one level to the other and, *a fortiori*, for describing the unity of levels of Reality.

If it does exist, the unity linking all the levels of Reality must necessarily be an open *unity*.

To be sure, there is a coherence of the unity of levels of Reality, but we must remember that this coherence is *oriented* : there is an arrow associated with all transmission of information from one level to the other. As a consequence of this, if coherence is limited only to the levels of Reality, it is stopped at the "highest" level and at the "lowest" level. If we wish to posit the idea of a coherence which continues beyond these two limited levels so that there is an open unity, one must conceive the unity of levels of Reality as a unity which is extended by a *zone of non-resistance* to our experiences, representations, descriptions, images and mathematical formalizations. Within our model of Reality, this zone of non-resistance corresponds to the "veil" which Bernard d'Espagnat referred to as "the veil of the real" [10]. The "highest" level and the "lowest" level of the unity of levels of Reality are united across a zone of absolute transparency. But these two levels are different; from the point of view of our experiences, representations, descriptions, images, and mathematical formalizations, absolute transparency functions like a veil. In fact, the open unity of the world implies that that which is "below" is the same as that which is "above". The isomorphism between "above" and "below" is established by the zone of non-resistance.

Quite simply, the non-resistance of this zone of absolute transparency is due to the limitations of our bodies and of our sense organs, limitations which apply regardless of the instruments of measure used to extend these sense organs. To claim that there is an infinite human knowledge (which excludes any zone of non-resistance), while simultaneously affirming the limitations of our body and our sense organs, seems to us a feat of linguistic sleight of hand. The zone of non-resistance corresponds to the sacred, *that is to say to that which does not submit to any rationalization*.

The unity of levels of Reality and its complementary zone of non-resistance constitutes *the transdisciplinary Object*.

A new *Principle of Relativity* [7] emerges from the coexistence between complex plurality and open unity : *no one level of Reality constitutes a privileged place from which one is able to understand all the other levels of Reality*. A level of Reality is what it is because all the other levels exist at the same time. This Principle of Relativity is what originates a new perspective on religion, politics, art, education, and social life. In the transdisciplinary vision, Reality is not only multi-dimensional, it is also multi-referential.

The different levels of Reality are accessible to human knowledge thanks to the existence of different *levels of perception*, which are in bi-univocal correspondence with levels of Reality. These levels of perception permit an increasingly general, unifying, encompassing vision of Reality, without ever entirely exhausting it.

As in the case of levels of Reality the coherence of levels of perception presupposes a zone of non-resistance to perception.

The unity of levels of perception and its complementary zone of non-resistance constitutes *the transdisciplinary Subject*.

The two zones of non-resistance of transdisciplinary Object and Subject must be *identical* in order that the transdisciplinary Subject can communicate with the transdisciplinary Object. *A flow of consciousness crossing the different levels of perception in a coherent manner must correspond to the flow of information crossing the different levels of Reality in a coherent manner*. The two flows are in a relation of *isomorphism* thanks to the existence of one and the same zone of non-resistance. Knowledge is neither exterior nor interior: it is *at the same time* exterior and interior. The study of the universe and the study of the human being sustain one another. The zone of non-resistance permits the unification of the transdisciplinary Subject and the transdisciplinary Object while preserving their difference.

Transdisciplinarity is the transgression of duality opposing binary pairs: subject/object, subjectivity/objectivity, matter/consciousness, nature/divine, simplicity/complexity, reductionism/holism, diversity/unity. This duality is transgressed by the open unity which encompasses both the universe and the human being.

The transdisciplinary model of Reality has, in particular, some important consequences in the study of *complexity*. Without its contradictory pole of simplicity (or, more precisely, *simplicity*) complexity appears as an increasingly enlarging *distance* between the human being and Reality which

introduces a self-destructive alienation of the human being who is plunged into the absurdity of destiny. The infinite simplicity of the transdisciplinary Subject corresponds to the infinite complexity of the transdisciplinary Object.

The Subject/Object problem was central for the founding-fathers of quantum mechanics. Pauli, Heisenberg and Pauli, as Husserl, Heidegger and Cassirer refuted the basic axiom of modern metaphysics: the clear-cut distinction between Subject and Object. Our considerations here are inscribed in the same framework.

4 The death and the resurrection of Nature

Modernity is particularly deadly. It has invented all kinds of "deaths" and "ends": the death of God, the death of Man, the end of ideologies, the end of history and, today, the end of science [11].

But, there is a death which is spoken of much less, on account of shame or ignorance : *the death of Nature*. In my view, this death of Nature is the source of all the other deadly concepts which were just invoked. In any case, the very word "Nature" has ended by disappearing from scientific vocabulary. Of course, the "man in the street", just as the scientist (in popularized works) still uses this word, but in a confused, sentimental way, reminiscent of magic.

Since the beginning of time we have not stopped modifying our vision of Nature [12]. Historians of science are in accord in saying that, despite all appearances to the contrary, there is not only one vision of Nature across time. What can there be in common between the Nature of so-called "primitive" peoples, the Nature of the Greeks, the Nature in the time of Galileo, of the Marquis de Sade, of Laplace or of Novalis? The vision of Nature of a given period depends on the imaginary which predominates during that period; in turn, that vision depends on a multiplicity of parameters: the degree of development of science and technology, social organization, art, religion, etc. Once formed, an image of Nature exercises an influence on all areas of knowledge. The passage from one vision to another is not progressive, continuous – it occurs by means of sharp, radical, discontinuous ruptures. Several contradictory visions can co-exist. The extraordinary diversity of visions of Nature explains why one cannot speak of Nature, but only of a certain nature in accord with the imaginary of a given period.

The image of Nature has always had a multiform action: it has influenced

not only science but also art, religion, and social life. This allows us to explain some strange synchronicities. Here I limit myself to but a single example: the simultaneous appearance of the theory of the end of history and of the end of science just before the beginning of the 3rd millenium. For example, unified theories in physics have as their aim the elaboration of a complete approach, founded on a unique interaction, which can predict everything (hence the name, "Theory of Everything"). It is quite obvious that if such a theory were formulated in the future, it would signify the end of fundamental physics, because there would be nothing left to look for. It is interesting to observe that both the idea of the end of history and of the end of science have simultaneously emerged from the "end of the century" imaginary.

Notwithstanding the abundant and fascinating diversity of images of Nature one can nevertheless distinguish three main stages: Magic Nature, Nature as Machine, and the Death of Nature. Magical thought views nature as a living organism, endowed with intelligence and consciousness. The fundamental postulate of magical thought is that of universal interdependence: Nature cannot be conceived outside of its relations with us. Everything is sign, trace, signature, symbol. Science, in the modern sense of this word, is superfluous.

At the other extreme, the mechanist and determinist thought of the 18th and above all the 19th century (which, by the way, still predominates today) conceives Nature not as an organism, but as a machine. It suffices to disassemble this machine piece by piece in order to possess it entirely. The fundamental postulate of mechanistic and determinist thought is that Nature can be known and conquered by scientific methodology, defined in a way which is completely independent of human beings and separate from us.

The logical outcome of the mechanist and determinist vision is the Death of Nature, the disappearance of the concept of Nature from the scientific field. From the very beginning of the mechanistic vision, Nature as Machine, with or without the image of God as watchmaker, is split up into an ensemble of separate parts. From that moment on, there is no more need for a coherent whole, for a living organism, or even, for a machine which still kept the musty odor of finality. Nature is dead, but complexity remains. An astonishing complexity (in fact, often confused with "complication"), which penetrates each and every field of knowledge. But this complexity is perceived as an accident; we ourselves are considered to be an accident of complexity.

The Death of Nature is incompatible with a coherent interpretation of the results of contemporary science, in spite of the persistence of the neo-

reductionistic attitude which accords exclusive importance to the fundamental building-blocks of matter and to the four known physical interactions. According to this neo-reductionist attitude, all recourse to Nature is superfluous and devoid of sense. In truth, Nature is dead only for a certain vision of the world – the classical vision.

The rigid objectivity of classical thought is only viable in the classical world. The idea of total separation between an observer and a Reality assumed to be completely independent from that observer brings us to the verge of insurmountable paradoxes. In fact, a far more subtle notion of objectivity characterizes the quantum world: objectivity depends on the level of Reality in question.

Space-time itself no longer rests on a fixed concept. Our space-time which proceeds in four dimensions is not the only conceivable space-time. According to certain physical theories, it appears more an approximation, like a part of a space-time all the more rich for being the generator of possible phenomena. Supplementary dimensions are not the result of mere intellectual speculation. On the one hand, these dimensions are necessary to insure the self-consistency of the theory and the elimination of certain undesirable aspects. On the other hand, they do not have a purely formal character – they have physical consequences for our own scale. For example, according to certain cosmological theories, if the universe had been associated from the "beginning" of the big bang in a multi-dimensional space-time, supplementary dimensions would have remained forever hidden, unobservable; rather, their vestiges would be precisely the known physical interactions. By means of generalizing the example provided by particle physics, it becomes conceivable that certain levels of Reality correspond to a space-time different than that characterizing our own level. Moreover, complexity itself would depend on the nature of space-time as well.

We can make, like Heisenberg made [4], a step further and assert that the classical four-dimensional space-time is, in fact, an *anthropomorphic concept*, founded on our sense-organs.

According to present scientific conceptions, *matter* is far from being identical with substance. In the quantum world, matter is associated with a *substance-energy-information-space-time complexus*.

It is somewhat mysterious why trajectories played such a central role in the formulation of modern physics. The quantum indeterminacy showed that trajectories are not a fundamental concept. In more recent years, a new discipline is born by the unexpected encounter between the theory of infor-

mation and quantum mechanics: the Quantum Theory of Information [13]. This new-born science already poses a crucial question : are the *information laws* more general, and therefore deeper, than the equations of movement? Are the central concepts of positions, speeds and trajectories of particles to be abandoned in favour of information laws which, in fact, could be valid not only for physics but also for other fields of knowledge? There were these last years fabulous experimental advances in the fields of non-separability, disentanglement, quantum cryptography and teleportation, in conjunction with the possible advent of quantum computers. This shows that notions like "levels of Reality" or "included middle" cease to be just theoretical speculations, by entering today in the field of experiments and, tomorrow, in the everyday life.

We can assert that the notion itself of *laws of Nature* completely changes its contents when compared with that of the classical vision. This situation can be summed up by three theses formulated by the well-known physicist Walter Thirring [14] :

1. *The laws of any inferior level are not completely determined by the laws of a superior level.* Thus, notions well anchored in classical physics, like "fundamental" and "accidental," must be re-examined. That which is considered to be fundamental on one level can appear to be accidental on a superior level and that which is considered to be accidental or incomprehensible on a certain level can appear to be fundamental on a superior level.

2. *The laws of an inferior level depend more on the circumstances of their emergence than on the laws of a superior level.* The laws of a certain level depend essentially on the local configuration to which these laws refer. There is therefore a kind of local autonomy of respective levels of Reality; however, certain internal ambiguities concerning laws of an inferior level of Reality are resolved by taking into account the laws of a superior level. It is the internal consistency of laws which reduces the ambiguity of laws.

3. *The hierarchy of laws evolves at the same time as the universe itself.* In other words, the *birth of laws* occurs simultaneously with the evolution of the universe. These laws pre-exist at the "beginning" of the universe as potentialities. It is the evolution of the universe which actualizes these laws and their hierarchy. A transdisciplinary model of Nature must integrate all this new knowledge of the emergent characteristics of the physical universe.

The Thirring's description of the laws of Nature is in perfect agreement with our own considerations about the Gödelian structure of Nature and knowledge. The problem of quantum indeterminacy can now be fully under-

stood as *the influence of the quantum level of Reality on our own macrophysical level of Reality*. Of course, the laws of the macrophysical level depend more, as Thirring writes, on "the circumstances of their emergence". From the point of view of the macrophysical level indeterminacy appears as accidental, incomprehensible, or at most as a rare event. But this reveals, in fact, an internal ambiguity which can be solved only by taking into account the laws of the quantum level. At this last level the indeterminacy is fundamental.

One can ask if one can not logically conceive a *generalized indeterminacy*, which goes far beyond the problem of trajectories of particles. Heisenberg already considered the *indeterminacy of language* [4] : the natural language can not express with arbitrary high precision all its elements, because the way of expressing acts in an essential manner on what is expressed. The indeterminacy of the natural language is just one example of the generalized indeterminacy generated by the Gödelian structure of Nature and knowledge.

In conclusion, we can distinguish three major aspects of Nature in accordance with the transdisciplinary model of Reality :

(1) *Objective Nature*, which is connected with the natural properties of the transdisciplinary Object; objective Nature is subject to subjective objectivity. This objectivity is subjective to the extent that the levels of Reality are connected to levels of perception. Nevertheless emphasis here is on objectivity, to the extent to which the methodology employed is that of science.

2) *Subjective Nature*, which is connected with the natural properties of the transdisciplinary Subject; subjective Nature is subject to objective subjectivity. This subjectivity is objective to the extent that the levels of perception are connected to levels of Reality. Nevertheless, emphasis here is on subjectivity, to the extent to which the methodology is employed is that of the ancient science of being, which crosses all the traditions and religions of the world.

3) *Trans-Nature*, which is connected with a similarity in Nature which exists between the transdisciplinary Object and the transdisciplinary Subject. Trans-Nature concerns the domain of the sacred. It cannot be approached without considering the other two aspects of Nature at the same time.

Transdisciplinary Nature has a ternary structure (objective Nature, subjective Nature, trans-Nature), which defines *living Nature*. This Nature is living because it is there that life is present in all its degrees and because its study demands the integration of *lived experience*. The three aspects of Nature must be considered simultaneously in terms of their inter-relation and

their conjunction within all the phenomena of living Nature [15].

The study of living Nature asks for a new methodology – transdisciplinary methodology [7] – which is different from the methodology of modern science and the methodology of the ancient science of being. It is the *co-evolution* of the human being and of the universe which asks for a new methodology.

An attempt to elaborate a new *Philosophy of Nature*, a privileged mediator of a dialogue between all the areas of knowledge, is one of the highest priorities of transdisciplinarity.

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- [7] Basarab Nicolescu, *La transdisciplinarité*, manifeste, Le Rocher, Paris, coll. "Transdisciplinarité", 1996. The word "transdisciplinarity", as carrying a different meaning from "interdisciplinarity", was first introduced in 1970 by Jean Piaget in *L'interdisciplinarité - Problèmes d'enseignement et de recherche dans les universités*, OCDE, Paris, 1972. From etymological point of view "trans" means "between, across, beyond". We mean by "transdisciplinarity" that which crosses all disciplines and finds itself between and beyond all disciplines. Therefore the transdisciplinarity is clearly not a new discipline. See also the Internet site of the International Center for Transdisciplinary Research (CIRET) <http://perso.club-internet.fr/nicol/ciret/> (materials in French, English, Portuguese and Spanish).
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- [15] In fact the term "living Nature" is a pleonasm, because the word "Nature" is intimately linked to that of "birth." The root of the Latin word, *natura is nasci* and designates the action of giving birth as well as the feminine organs of generation.